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PREFACE

This report summarizes the results of an economic analysis of the likely effects of a proposed sand and gravel mine in Soledad Canyon, just east of the City of Santa Clarita in Los Angeles County. The analysis attempts to better understand the likely effects of the proposed mine on the price of construction aggregate (crushed stone, sand, and gravel), the costs of transporting aggregate, and the amount of aggregate reserves in the greater Los Angeles metropolitan area. This analysis does not consider any other potential impacts of the proposed mine, such as environmental, safety and health, or local community impacts.

Because of its limited scope, this analysis should not be used by itself in making policy decisions regarding the Soledad Canyon Project. Rather, the proposed mine should be assessed in conjunction with additional studies addressing the complete spectrum of costs and benefits associated with the project, including traffic, road maintenance, housing prices, health and safety, and environmental impacts.

This project was conducted jointly through the RAND Environment program and Enterprise Analysis unit within RAND, and was funded by the City of Santa Clarita.

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EXECUTIVE SUMMARY

This study addresses the economic impact of Transit Mixed Concrete Company's proposed sand and gravel mining project in Soledad Canyon, Los Angeles County, California. The plan calls for mining 56 million tons of sand and gravel over 20 years to supply the local construction aggregate market. In conducting this study, we assume that the mine operates between 2003 and 2022 and analyze how the mine would affect the costs of transporting aggregate, economic profits in the industry, the price of aggregate, and the reserves of aggregate in the greater Los Angeles metropolitan area through 2027.

In deciding whether or not to proceed with the Soledad Canyon Mine, policymakers should compare the costs of proceeding with the mine with the benefits. This analysis uses a simulation model developed for this project to addresses the potential benefits—namely the reductions in transportation costs and aggregate prices and the increase in aggregate reserves that might result from proceeding with the mine. It does not consider the costs. Potential costs of proceeding with the mine include a decline in property values, an increase in traffic congestion, damage to the environment, and the loss of recreational and scenic areas near the project. The results of this study should be combined with estimates of other benefits and costs to determine whether or not to proceed with the proposed project.

Our conclusions in each of the four categories examined follow.

TRANSPORTATION COSTS

With or without the mine, the annual cost of transporting aggregate throughout the area would nearly double between 2003 and 2027. This increase reflects both increased demand and longer transportation distances. If the mine is not permitted, transportation costs between 2003 and 2027 would likely total \$2.5 to \$3.4 billion.

The Soledad Canyon Mine would reduce transportation costs. Between 2003 and 2027 transportation costs with the mine (discounted to year 2000 dollars) would be lower than those without the mine by

- between \$24 million to \$61 million, or between 0.9 and 1.8 percent
- an average of \$1.0 to \$2.4 million per year between 2003 and 2027.

The reduction in transportation costs represents savings to society as a whole due to the reduced fuel, labor, and equipment costs of transporting aggregate from the mine to the consumer.

ECONOMIC PROFITS AND EXPENDITURES ON AGGREGATE

Economic profits, combined with production and transportation costs, determine how much consumers spend on aggregate. Without the mine, discounted expenditures will likely range from $8.1 and $9.2 billion between 2003 and 2027. Compared to levels without the mine, we find that the proposed mine

- may either increase or decrease the economic profits of the region's mining industry.
- would reduce discounted expenditures on aggregate by between $12 million and $222 million, or 0.1 and 2.4 percent.

This entire savings does not, however, represent a savings to society as a whole because the economic profits represent only a transfer from consumers to producers.

PRICE OF AGGREGATE

Lower expenditures reflect lower aggregate prices, and the Soledad Canyon Mine will likely reduce aggregate prices. We find that

- the mine would lower prices in the region by between 0.2 and 2.2 percent on average over time (or from roughly $10.00 per ton to between $9.80 and $9.98 per ton)
- the maximum price decline in any one year would be 4.5 percent (or roughly $0.45 per ton).

The effect of this range of price increases on construction activity and overall economic activity in the greater Los Angeles metropolitan area is unknown, but to put the price changes in perspective, we examined their effects on the costs of housing and highways. Based on typical aggregate use in construction, the results of our analysis indicate that the price reductions due to the Soledad Canyon Mine translate to a maximum savings of approximately 0.05 (5/100) percent (or $117) on a typical single family residence and between 0.1 and 0.5 percent (or $10,000 out of $2 million to $10 million) on the construction cost of one lane-mile of highway.

AGGREGATE RESERVES AND RESOURCES

The amount of reserves left in our simulations at the end of 2027 suggests that permitting new resources will remain an issue in the future whether or not the Soledad Canyon Mine is permitted. Given the rates of consumption projected for the future,

- the reserves remaining in 2027 may last between 2 and 25 additional years depending on the amount of resources converted to reserves between 2003 and 2027
- permitting the mine will have little effect on the situation—the 56 million tons that will be mined during the mine's lifetime represent less than one year of consumption at the consumption rates predicted for the future.

The projected growth in consumption and the continued pressure on reserves points to the critical need for a comprehensive, long-term policy for construction aggregate supply in the greater Los Angeles metropolitan area. There will be plenty of resources left in 2027 with or without the mine (between 12.5 and 12.9 billion tons) as long as even a relatively modest fraction is not encroached upon by urban development. Thus, the opportunity for permitting more reserves will remain. Permitting the Soledad Canyon Mine alone in the absence of a more comprehensive plan will make little difference to the amount of reserves available to the region. Focusing on long-range and region-wide strategies rather than single mines may provide the opportunity to satisfy construction aggregate demand in a way that is more amenable to the needs of all stakeholders. Strategies may include substantially reducing the amount of virgin aggregate that is used in construction, permitting resources far in excess of those permitted by the proposed mine, or planning projects that reduce the costs of transporting aggregate from greater distances.

ACKNOWLEDGEMENTS

Russell Miller of the California Division of Mines and Geology provided invaluable assistance in understanding aggregate supply in southern California and informally reviewed this report. Pablo Gutierrez at the Southern California Association of Governments created detailed maps of the greater Los Angeles metropolitan area on short notice. Several people at RAND also made important contributions to the project. We gratefully acknowledge Mark Hanson for his assistance with the research and editing. We thank Victoria Greenfield for her insightful comments in a formal review and Mark Bernstein for his helpful guidance and project management. D.J. Peterson helped define the initial project scope and directed us to population forecasts for the region. Pat Williams formatted and corrected the document, and Rae Archibald and Steve Rattien provided constructive comments on the final draft.

1. INTRODUCTION AND SCOPE

Transit Mixed Concrete Company proposes to build a new sand and gravel mine in Soledad Canyon in Los Angeles County, California. The project plan calls for mining 56 million tons of sand and gravel over 20 years from a 460-acre site approximately two miles east of the city of Santa Clarita.[1] The purpose of this analysis is to help estimate the economic impact of the proposed project on the aggregate industry in the greater Los Angeles metropolitan area.

1.1 THE AGGREGATE INDUSTRY IN THE GREATER LOS ANGELES METROPOLITAN AREA

Construction aggregate (crushed stone, sand and gravel) is used in virtually all construction projects, primarily in the form of concrete, asphalt, road base, fill, and plaster. Aggregate is supplied from naturally occurring sand and gravel deposits, such as alluvial fans, stream channels, and glacial deposits, as well as from crushed stone or "hard rock" deposits such as limestone or granite. The Los Angeles area has a relatively abundant supply of high quality aggregate, most of which is portland cement concrete grade. Based on the most recent assessment, the greater Los Angeles metropolitan area (Ventura, Los Angeles, Orange, western Riverside, and western San Bernardino Counties) has substantial aggregate resources (over 14 billion tons in 1993) and, as of 1993, nearly 2 billion of these 14 billion tons were permitted for extraction (see Table 1).[2] Adding the Soledad Canyon Project would increase the amount of aggregate permitted for extraction (so-called aggregate reserves) by approximately 3 percent.

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[1]More comprehensive descriptions of the project can be found in the Draft Environmental Impact Report (Los Angeles County Department of Regional Planning, 1999, 2000) and in reports by Brown and Frates (2000) and Boarnet (2000).

[2]As defined by the California Division of Mines and Geology (e.g., Miller, 1994), reserves are those aggregates that have been determined to be suitable for commercial use, that exist within properties owned or leased by aggregate producing companies, and for which permits have been issued to allow mining. Resources include reserves as well as all potentially usable aggregates that are technologically and economically available but for which no permit has been granted.

Table 1

Aggregate Resources and Reserves in 1993 and Maximum Annual Historic Production in the Greater Los Angeles Metropolitan Area

Production Region	Reserves in 1993 (millions of tons)	Resources in 1993 (millions of tons)	Historic Maximum Annual Production Rate (millions of tons per year)
West Ventura	4	141	4.0
Simi Valley	156	720	3.4
Saugus-Newhall	158	7,439	2.0
Palmdale	207	1,769	4.0
San Fernando	45	259	16.0
San Gabriel	334	1,645	20.0
Claremont-Upland	10[a]	1,304	4.0
Orange	84	557	5.7
Temescal Valley	924	1,026[b]	12.0
Total	1,922	14,860	69.7

Sources: Miller (1993, 1994a, 1994b), Miller et al. (1991), Cole (1987).
[a]Estimated from reported values for the Los Angeles County portion of this region.
[b]Minimum estimate (Miller et al., 1991).

Demand for construction aggregate in Southern California has increased over time. During the 1980s, use of aggregate rose from 30 million tons per year to nearly 60 million tons per year before falling back to roughly 30 million tons per year during the recession in the early 1990s.

The production cost of construction aggregate is relatively low compared to transportation costs. For example, the retail cost of construction aggregate trucked 40 miles is approximately double that of aggregate sold at the source. As a result, most aggregate users are supplied by sources located within 30 to 50 miles. Aggregate mines are therefore more numerous than other types of mining operations, with over 5,000 active aggregate mines and quarries in the United States, compared to about 1,500 coal mines and 500 metals mines. In 1999 there were 33 active aggregate mining operations in the greater Los Angeles metropolitan area (Beeby et al., 1999).

1.2 PURPOSE OF THIS ANALYSIS

This analysis examines the likely effect of the proposed Soledad Canyon Mine on the aggregate industry in the greater Los Angeles metropolitan area. In particular, it examines the effect of the mine on

- the price of aggregate throughout the region

- the costs of transporting aggregate in the region.

Changes in the price of aggregate are of concern because of their impact on construction costs and potentially on construction activity, and economic activity more generally, in the region. Aggregate prices are determined by the cost of producing aggregate (production costs), the costs of transporting it from the mine to the consumer (transportation costs), and the price premium suppliers can charge in a production-limited market (economic profits of the mining companies). The likely impact of the proposed mine on each of these determinants of price is examined.

Particular attention is paid to how the proposed mine would affect transportation costs. This is because any reduction in transportation costs due to the mine is the primary benefit of the mine to the region. It is unlikely that the mine will change the cost of producing aggregate in the region. And, any change in economic profits due to the proposed mine represents a transfer from consumers to producers and thus is of no net benefit to the region as a whole.

Changes in aggregate prices and transportation costs do not constitute the total economic impact resulting from the proposed project. In particular, other factors associated with the project such as changes in traffic, road maintenance, housing prices, health & safety, and environmental issues may have substantial economic impacts as well. For this reason, this analysis should not be used by itself in making policy decisions regarding the Soledad Canyon Mine. Rather, it should be assessed in conjunction with additional studies addressing a more complete spectrum of costs and benefits associated with the project.

2. ANALYTIC APPROACH

We constructed a quantitative model of the aggregate industry in the greater Los Angeles metropolitan area that predicts aggregate prices and transportation costs. We formulated a range of potential future scenarios based on different assumptions regarding key demand and supply parameters and predicted the outcomes of interest both with and without the proposed Soledad Canyon Mine. The difference between the with and without predictions is then the impact due to the mine.

In this section, we first conceptually discuss how the proposed mine may affect aggregate prices and transportation costs. Then we provide an overview of the simulation model.

2.1 CONCEPTUAL DISCUSSION OF THE EFFECTS OF THE MINE

The proposed Soledad Canyon Mine will likely reduce the costs of transporting aggregate from mines to users. As will be discussed below, the proposed mine increases both the reserves and annual production capacity in an area close to major population centers in the greater Los Angeles metropolitan area. Thus, opening the mine will likely mean lower transportation costs for the region as a whole.

The proposed mine will also affect the economic profits of the mining industry. Economic profits are defined as profits in excess of the normal return on capital (or as accounting profits less the normal return on capital). Economic profits are earned in periods of scarcity when demand for aggregate in a particular area outstrips the production capacity in the area. Suppliers may be able to raise their prices to match the retail costs of the next closest competitor. The difference between this price and the production cost represents mining company economic profit. A number of different factors determine economic profits (e.g., the distribution of demand, reserves, and production capacity in the region) and it is not obvious how they would be affected by the proposed mine. On the one hand, the proposed mine may relax supply constraints and thus reduce the economic profits in the industry. On the other hand, the added aggregate reserves may lengthen the time a mine in a supply-constrained area remains in business and thus generates economic profits.

As discussed in Section 1, the change in the price of aggregate is determined by the change in transportation costs and the change in economic profits (as well as the change in production costs, but we do not expect production costs to change much). Addition of

the Soledad Canyon Mine will always decrease regional transportation costs, but in some scenarios these savings may be offset by increased profits and thus not passed on to consumers. The net effect of the mine on price is therefore ambiguous in theory because a reduction in transportation costs may either be compounded or offset by a change in economic profits.

2.2 OVERVIEW OF SIMULATION MODEL

The area covered in our model includes Ventura, Los Angeles, Orange, western Riverside, and western San Bernardino Counties (see Figure 1). This encompasses all of the aggregate resources and production regions serving the Los Angeles Metropolitan Area as defined by the California Division of Mines and Geology (Beeby et al., 1999). As a whole, this area is approximately self-contained in terms of production and consumption, with very little aggregate moving in or out. It is therefore a practical analysis region in that there are no complications from aggregate "leakage".

Aggregates are supplied by nine different production regions, taken to be the same production regions defined by the California Division of Mines and Geology (Miller, 1993, 1994a, 1994b; Miller et al., 1991; Cole, 1987).[3] Each production region actually contains from two to seven individual mining operations, but aggregate reserve and production data for individual mines are unavailable for reasons of confidentiality. In most cases all of the individual operations in a particular production region are closely co-located, justifying treating an entire production region as being located at a single point. As discussed in Appendix A, however, we do assume that individual companies within a given production region compete with each other. The Soledad Canyon Project site is located within the Saugus-Newhall production region.

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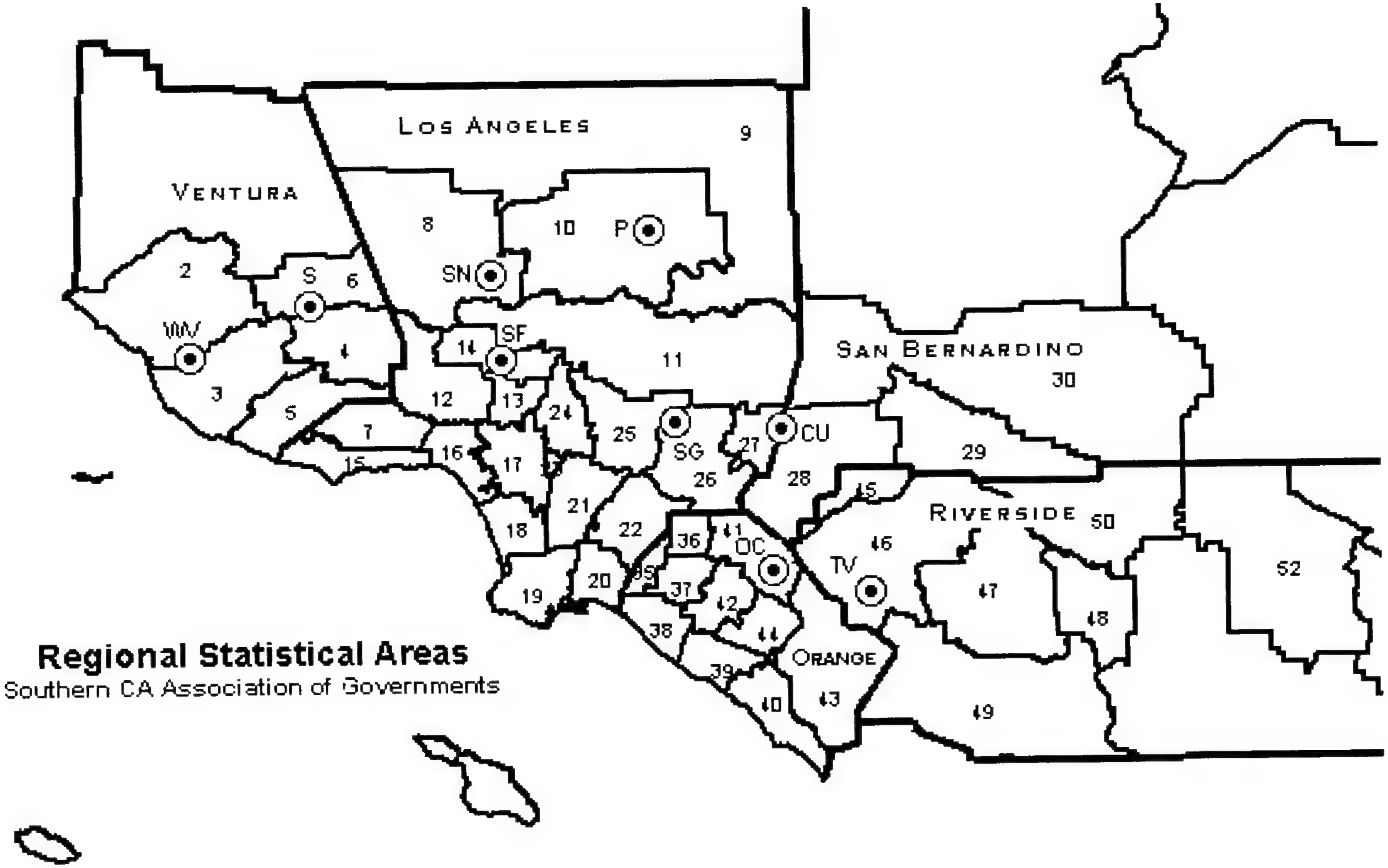
[3]One of the production regions is West Ventura. This production region is currently closed, but in 1993 when the simulations begin (as discussed below), it was open.



Note: Numbered consumption areas are taken from the Regional Statistical Areas of the Southern California Association of Governments (1998). Production regions are marked by ◉ , where WV = Western Ventura, S = Simi Valley, SN = Saugus Newhall, SF = San Fernando, SG = San Gabriel, CU = Claremont-Upland, OC = Orange County, and TV = Temescal Valley.

Figure 1--Production Regions and Consumption Areas in the Greater Los Angeles Metropolitan Area

Aggregate is consumed by 46 individual consumption areas, which are taken to be the Regional Statistical Areas defined by the Southern California Association of Governments. Because of their small size (typical dimensions of 5 - 15 miles) each consumption area is treated as a single point. We assume that aggregate demand in each consumption area is directly related to population, with population projections over time in each consumption area taken from the Southern California Association of Governments (Southern California Association of Governments, 1998). This is an approximation made necessary by a lack of more detailed data and does not capture all of the potential demand drivers (such as community maturity, large construction projects, re-development, or aggregate price) that can vary across consumption areas and over time.[4]

Suggestions for alternative demand formulations have been discussed by previous analysts, but in the studies we have reviewed, projected demand continues to be calculated from population projections alone. This is the assumption used by the California Division of Mines and Geology in their demand projections as well as in studies by Boarnet (2000) and Brown and Frates (2000). Further work is warranted on the sensitivity of aggregate demand to different drivers, particularly price, and on the effects of the proposed mine when these drivers are accounted for.

Given the total aggregate reserves and annual production capacity in each production region and the demand in each consumption area, the model predicts the amount of aggregate sold by each production region to each consumption area each year. This production and distribution pattern is determined by minimizing the transportation costs for the entire study area, which, as detailed in Appendix A, approximates how production decisions would be made in a competitive industry. A set of prices for the consumption areas is derived that is consistent with the production and distribution pattern (consumers in each consumption area do not have incentives to buy from other producers), and this set of prices is used to determine economic profits in the production regions.

[4]We made the simplification of using a single, region-wide, per-capita consumption rate in each area because 1) we divided the region into different (and far more) consumption areas than those for which consumption is reported; 2) given the historical fluctuations in aggregate consumption and complex demand drivers, we felt it was too difficult to project local consumption differences into the future; and 3) some of the difference in reported per capita consumption is an artifact resulting from the fact that aggregate consumption is typically calculated from aggregate production, and reported consumption can be higher than actual consumptions in production regions that produce aggregate that is consumed elsewhere.

At the end of each year, reserves are reduced by the amount of resources extracted during the year, and the process repeats. The most recent year for which aggregate reserve data are available is 1993, so the model starts in 1994. We set the opening date for the proposed Soledad Canyon Mine at 2003 and allow it to operate for 20 years. We run the model through 2027, five years after the mine is expected to close. All costs and profits are discounted back to year 2000 dollars.

This model differs in three key ways from those of Boarnet (2000) and Brown and Frates (2000). First, it covers a larger total area and eliminates uncertainties associated with aggregate leakage in or out of the study area. Second, it defines far more individual consumption areas (46 as compared to 4 to 6), allowing a much more realistic simulation of actual aggregate transportation requirements. Third, by modeling profits and production at all the production regions in the greater Los Angeles metropolitan area, the model more systematically addresses the ripple effects of increased production at the Soledad Canyon mine on the profits and production at the other production regions in the region. We feel that these differences allow our model to more accurately and objectively simulate aggregate supply and demand.

3. SCENARIOS AND ASSUMPTIONS

This section details the parameter values used in the model simulations and the rationale for selecting them. For each parameter, we select a base-case value and a range of values that bracket the base-case value. The base-case values represent our estimate of the most likely values of the parameters and are used in the base-case prediction of the effects of the proposed Soledad Canyon Mine. There is a great deal of uncertainty about the values of most of the parameters used in the predictions, however, and we use the parameter ranges to develop credible ranges into which the effects of the proposed mine are likely to fall.

We begin by describing the base-case values and ranges for the parameters used in the analysis:

- aggregate supply
- annual production capacity constraints
- aggregate production and transportation costs
- aggregate demand.

We conclude by discussing the parameter values used to determine the credible ranges for the effects of the proposed mine.

3.1 AGGREGATE SUPPLY

The available aggregate resources and reserves at each production region as of 1994 are given in reports by the California Division of Mines and Geology (Miller, 1993, 1994a, 1994b; Miller et al., 1991; Cole, 1987; Table 1). With two exceptions, we estimated aggregate reserves in each production region available for extraction between 1994 and 2027 to be the existing reserves plus 10 percent of the resources in that production region (see first two columns of Table 2A). In the Saugus-Newhall production region, the only addition is the Soledad Canyon Mine (increasing reserves from 158 million tons without the mine to 214 tons with the mine), which accounts for less than 1 percent of the resources in this region. Reserves in the West Ventura production region were not increased because this region closed in the mid-1990s.

Table 2A

Reserves and Production Limits Used in the Base-Case Prediction

	Augmented Reserves in 1993 (million tons)[a]		Annual Production Capacity Limit, 2003- 2027 (million tons per year)[b]	
Production Region	With Mine	Without Mine	With Mine	Without Mine
West Ventura	4	4	4.0	4.0
Simi Valley	228	228	5.0	5.0
Saugus-Newhall	214	158	--	--
1993-2002	--	--	2.0	2.0
2003-2012	--	--	3.4[c]	2.0
2013-2022	--	--	6.2[c]	2.0
2023-2027	--	--	2.0	2.0
Palmdale	384	384	20	20
San Fernando	71	71	25.3	25.3
San Gabriel	499	499	29.8	29.8
Claremont-Upland	140	140	56.0	56.0
Orange	140	140	9.4	9.4
Temescal Valley	1,027	1,027	50	50
Total	2,707	2,651	205.7	201.5

[a]Amount of reserves used in simulation model.

[b]Production capacity limits from 1993 to 2002 in the model are held at the historic maximum (Table 1).

[c]Based on projected annual production for the Soledad Canyon Mine of 1.4 million tons/year during the first 10 years and 4.2 million tons/year during the second 10 years (Boarnet, 2000).

Permitting 10 percent of existing resources between 1994 and 2027 (34 years) is consistent with previous permitting rates for these production regions. Data reported by the California Division of Mines and Geology indicate that, over the 8 to 12 years between their initial and updated aggregate resource assessments, a total of 4 percent of the existing resources have been permitted in the production regions we are considering (Miller, 1993, 1994a, 1994b; Miller et al., 1991; Cole, 1987). These new reserves comprise both augmentations of existing permitted deposits as well as newly permitted material. Extrapolating this rate forward results in the permitting of 11 to 17 percent of existing resources over the next 34 years. We use 10 percent for our base case (Table 2A). We also examine the effects of increasing reserves by 5 percent and 25 percent of resources—we consider values less than 5 percent or greater than 25 percent unrealistic based on previous permitting rates.

3.2 ANNUAL PRODUCTION CAPACITY

Annual production capacities for production regions are difficult to estimate, as actual production varies with demand. Given that historical outputs for most production regions fluctuate up and down with time, it appears that production at most sources is not always capacity constrained. We therefore assume that production capacity can increase over the 25 years of the analysis, with the amount of increase linked to the increase in permitting: in the base case, annual production capacity limits for each production region are set to the historical maximum for that region (Table 1) adjusted by the proportional increase in reserves resulting from permitting of 10 percent of the resources. The resulting values are listed in the last two columns of Table 2A.

In order to ensure that total regional demand could be satisfied each year, production capacity limits for the Temescal Valley and Palmdale production regions are increased by greater factors. Because of their large reserve bases and relatively lower population densities, these regions produce more than required by local demand. All of the companies operating in the Temescal Valley area sell material outside the region, primarily to Orange and San Diego Counties (Miller et al., 1991). In fact, over 70 percent of the aggregates consumed in Orange County are supplied from the Temescal Valley production region (Miller, 1994). Thus, the production capacities for the Temescal Valley and Palmdale regions are allowed to rise to 50 and 20 million tons per year, respectively.

As shown in the last two columns of Table 2A, the proposed Soledad Canyon Mine increases the annual production limits in the Saugus-Newhall production region. Based on projected annual production from the proposed mine, annual production capacity in Saugus-Newhall jumps from 2.0 million tons between 1994 and 2002 to 3.2 million tons between 2003 and 2012 and to 6.2 million tons between 2013 and 2022 (Boarnet, 2000). Annual production capacity is assumed to return to pre-mine levels in 2023 once the proposed mine closes.

In our analysis, we also consider other plausible annual capacity constraints ranging from the historic maximum production to twice the base-case values. For both alternatives, we do not change the Saugus-Newhall, Palmdale, or Temescal Canyon limits from their base-case values.

3.3 PRODUCTION AND TRANSPORTATION COSTS

Aggregate production cost was approximated as $5.80 per ton (see first column of Table 2B), the 1998 free-on-board, or pre-transportation, price for construction sand and

gravel in California District 11 (Ventura, Los Angeles, and Orange Counties; U.S. Geological Survey, 1999).[5] This value was held constant in all scenarios and across all production regions.

Transportation costs are calculated from transportation distances and tonnage using a relationship derived from the data in Beeby et al. (1999): \$ per ton-mile = $0.639*(\text{miles})^{-0.442}$. This relationship gives cost ranging from \$0.31 per ton-mile at 5 miles to \$0.13 per ton-mile at 35 miles (see Table 2B). Transportation distances were determined from linear measurements between production regions and the centroids of each consumption area (see Figure 1). The one exception is that aggregate from Palmdale must move down through the Highway 14 corridor to reach other parts of the greater Los Angeles metropolitan area.

[5]Production costs cover the cost of extracting and processing aggregate at the mine. They include a normal return on capital, but do not include transportation costs and economic profits. Because production costs do not include economic profits, they may be less than the free-on-board price at the mine.

Table 2B

Parameters Used in the Base Case and to Develop Credible Ranges for Economic Impact of Proposed Mine

	Base Case	Transportation Costs		Prices and Economic Profits	
		Small Impact	Large Impact	Small Impact	Large Impact
Supply Parameters					
Reserves of Aggregate	Existing plus 10% of resources (Table 2A)	Existing plus 25% of resources	Existing plus 5% of resources	Existing plus 5% of resources	Existing plus 25% of resources
Annual Production Capacity	Historic maximum plus increase proportional to increase in reserves (see Table 2A)	2 times base case	Base case	Historic max	Base case
Transportation Cost ($/ton-mile)[a]					
5 miles	0.31	----[b]	----	----	----
15 miles	0.19	----	----	----	----
25 miles	0.15	----	----	----	----
35 miles	0.13	----	----	----	----
Production cost ($ per ton)	5.80	----	----	----	----
Demand Parameters					
Annual per capita use (tons/person-year)	3.4	3.1	3.4	3.1	3.7
Population (millions)					
2000	16.3	----	----	----	----
2010	18.6	----	----	----	----
2020	21.1	----	----	----	----
2027	23.0	----	----	----	----
Discount Rate (percent)	4.5	----	----	----	----

[a] $ per ton-mile = $0.639*(\text{miles})^{-0.442}$ (see text).
[b] Entries marked with "----" were not changed in the small and large impact simulations.

3.4 AGGREGATE DEMAND

Our base-case annual per capita consumption rate of 3.4 tons per person-year is the mean value for Los Angeles County from 1966 to 1992 taken from Miller (1994a; Table 2B). The consumption rate for the greater Los Angeles metropolitan area shows no systematic trend with time, although there are transient fluctuations (Beeby et al., 1999). Although the most recently available value is 2.5 tons per person-year in 1997, this appears to be anomalously low as consumption was recovering from a recession. We varied annual per capita consumption from 3.1 to 3.7 tons per person-year, which is the 95 percent confidence interval for the estimate of the mean average annual per capita consumption from 1966 to 1992. The per capita annual consumption rate does not vary across consumption areas in a given scenario..

3.5 PARAMETER VALUES USED TO DEVELOP CREDIBLE RANGES

We first predicted the impact of the proposed mine using the base-case set of parameter values and then examined the effects of the mine varying each parameter one at a time through its specified range. The results are presented and discussed in Appendix B. Based on the results of this analysis we selected parameter values with which to construct the upper and lower bounds of the credible ranges for program effects. These parameter values are listed in the last four columns of Table 2B. Because the parameter values that produce small and large effects for transportation costs differ from those that produce small and large effects for prices and economic profits, we use different parameter values in constructing the credible range for each. The parameter values used to construct the credible range for transportation costs are listed in the second and third columns of Table 2B. Those used to construct the credible range for prices and economic profits are listed in the last two columns of Table 2B.

4. PREDICTED EFFECTS OF THE PROPOSED SOLEDAD CANYON MINE

In this section we present predicted effects of the proposed Soledad Canyon Mine on the aggregate industry in the greater Los Angeles metropolitan area. We present results both for a base case and for the ranges into which the mine effects will likely fall (the credible ranges). We first discuss how the mine is likely to affect the cost of transporting aggregate before turning to the likely effects on mining profits and consumer expenditures on aggregate. We then examine the likely effects of the proposed mine on aggregate prices and conclude with the effects on aggregate reserves remaining and the number of production regions remaining in operation in 2027.

4.1 TRANSPORTATION COSTS

The annual transportation costs for the region with and without the proposed mine in the base-case prediction are shown in Figure 2. Transportation costs increase over time as production capacities are reached and reserves are depleted in particular production regions. The large increase starting in 2013 is the result of the depletion of some of the production regions, forcing customers to transport their aggregates from further away. The Soledad Canyon Mine both increases the production capacity and extends the amount of aggregate that can be extracted in the Saugus-Newhall production region. As shown in Figure 2, these increases reduce the increase in annual transportation costs. The reductions in transportation costs persist as long as the mine is open, but once the mine closes (2022), transportation costs with the mine return to those in the without-mine scenario. With or without the mine, the total annual costs of transporting aggregate nearly double between 2003 and 2027, reflecting both increased demand and longer transportation distances.

Total transportation costs in the base case between 2003 and 2027 (discounted to year 2000 dollars) amount to \$3.129 billion with the mine and \$3.188 billion without the mine (see first row of Table 3). Thus, the reduction in transportation costs due to the proposed mine is \$59 million, or 1.9 percent. This reduction averages \$2.4 million per year between 2003 and 2027.

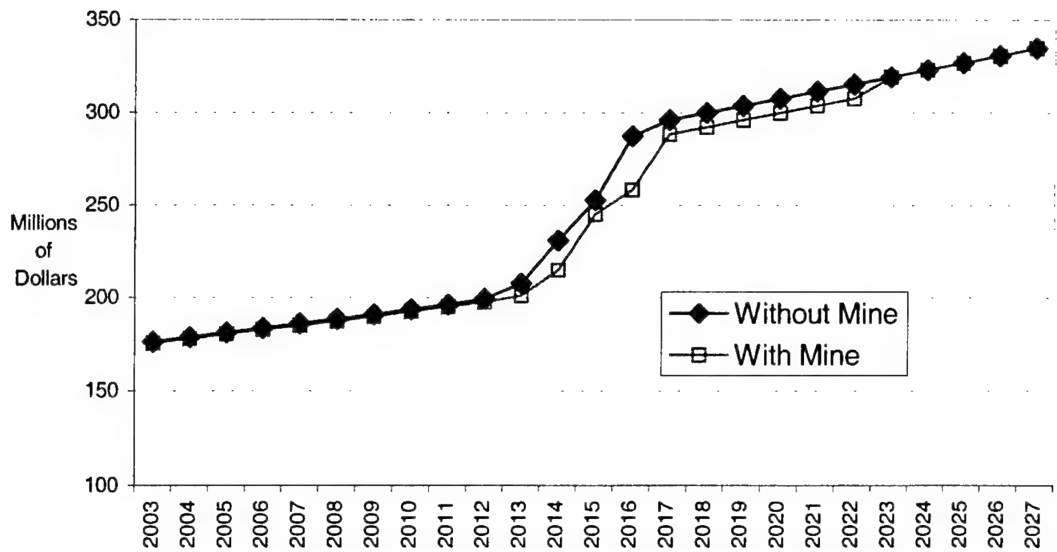


Figure 2—Cost of Transporting Aggregate in the Greater Los Angeles Metropolitan Area With and Without the Soledad Mine in the Base Case (millions of dollars, not discounted)

The last two sets of columns in Table 3 report credible ranges for the various outcomes of interest. We predict that the proposed mine will reduce transportation costs between 0.9 percent and 1.8 percent, or $24 million and $61 million, over the life of the project. Our base-case prediction happens to fall near the upper end of this credible range.

This reduction in transportation costs represents the savings to society as a whole due to the proposed mine.

Table 3

Predicted Effects of the Proposed Soledad Canyon Mine

	Base Case				Small Mine Effects			Large Mine Effects		
	With Mine	Without Mine	Change With Mine	Percent Change	Without Mine	Change With Mine	Percent Change	Without Mine	Change With Mine	Percent Change
Transportation cost 2003-2027 ($millions)[a]	3,129	3,188	-59	-1.9	2,534	-24	-0.9	3,352	-61	-1.8
Total expenditures on aggregate 2003-2027 ($millions)[a,b]	8,410	8,472	-62	-0.7	8,124	-12	-0.1	9,157	-222	-2.4
Average Price of Aggregate ($/ton)[c]										
2003	8.87	8.90	-0.02	-0.3	9.80	<-0.01	<-0.1	9.24	-0.36	-4.0
2007	8.88	8.90	-0.02	-0.3	9.79	<-0.01	<-0.1	9.24	-0.17	-1.8
2012	8.90	9.24	-0.34	-3.7	9.89	<-0.01	<-0.1	9.37	-0.02	-0.2
2017	10.21	10.22	-0.01	-0.1	10.23	-0.01	-0.1	9.42	-0.41	-4.3
2022	10.21	10.22	-0.01	-0.1	10.22	<-0.01	<-0.1	9.68	-0.01	-0.1
2027	10.21	10.21	0	0	10.47	-0.23	-2.2	10.21	0	0
Reserves Remaining in 2027 (millions of tons)	534	478	56	11.7	1,752	56	3.1	142	56	39.4
Resources Remaining in 2027 (millions of tons)	12,688	12,688	0	0	12,879	0	0	12,496	0	0
Production Regions Operating in 2027	4	4	0	0	5	0	0	4	0	0

[a]Discounted to year 2000 dollars.
[b]Sum of production, transportation costs and economic profit
[c]Average price calculated by taking weighted average of prices in each consumption area with weights based on the use in each consumption area.

4.2 MINING PROFITS AND CONSUMER EXPENDITURES ON AGGREGATE

Annual economic profit for the aggregate industry in the base case is shown in Figure 3. Without the mine, economic profits rise beginning in 2009 as production in some production regions start to run up against annual production limits. Profits fall in 2015 because production in the large San Gabriel production region ceases due to exhaustion of reserves. With the proposed mine, the rise in mining industry profits is delayed, but profits remain at higher levels between 2017 and 2022 because the Saugus-Newhall area can operate at a higher annual production level. The sharp drop in 2015 with the proposed mine is also due to the closure of the San Gabriel production region—profits rise in the following year as production in the Claremont-Upland region reaches its annual production limit and then fall the next year when reserves in Claremont-Upland are exhausted.

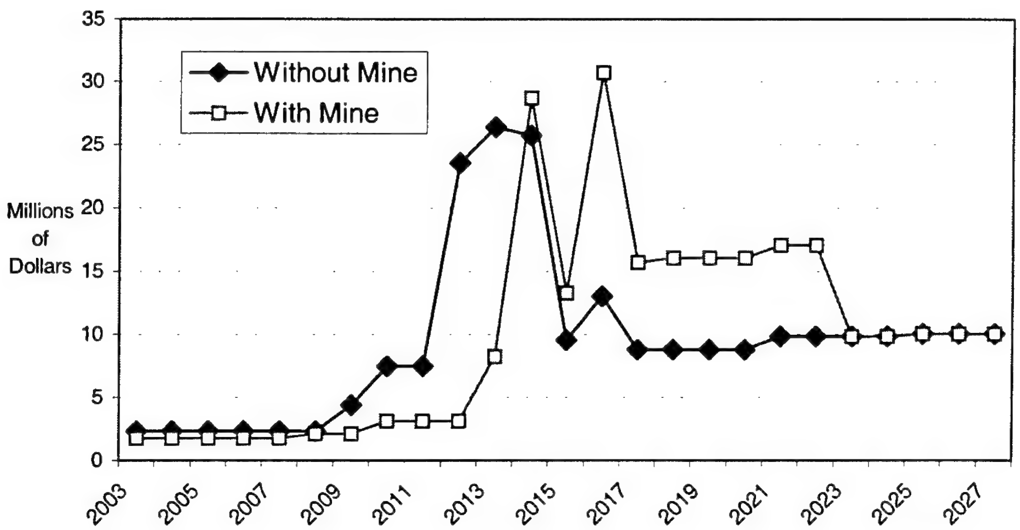


Figure 3—Mining Industry Economic Profits in the Greater Los Angeles Metropolitan Area With and Without the Soledad Mine in the Base Case (millions of dollars, not discounted)

When discounted to back to year 2000 dollars, the difference in profits with and without the mine in the base case is small. The second row of Table 3 shows total expenditures on aggregate in the greater Los Angeles metropolitan area, which is the sum of production costs, transportation costs, and economic profits. Without the mine, discounted expenditures are $8.5 billion between 2003 and 2027. With the mine, discounted expenditures are $62 million lower, which reflects the sum of the difference in

transportation costs ($59 million lower) and economic profits ($3 million lower). Because annual consumption, and thus annual production, are the same with and without the mine, discounted production costs with and without the mine are the same (approximately $5.2 billion over the entire period).

As shown in Table 3, the credible range for the reduction in total expenditures on aggregate between 2003 and 2027 due to the proposed mine ranges from $12 million to $222 million. At the low end of this range, the lower transportation costs due to the proposed mine are partially offset by higher mining profits. At the high end, lower mining profits due to the mine compound lower transportation costs.

Two observations about these results are warranted. First, while the proposed mine always reduces transportation costs, it increases mining profits in some scenarios and decreases mining profits in others. This change sign is due to changes in the relative importance of the various (conflicting) factors that determine profits in the different scenarios (see discussion in Section 2.1). Second, economic profits represent a transfer from consumers of aggregate to producers.[6] Thus, the $12 million to $222 million range for the reduction in transportation costs plus economic profits due to the mine does not represent a savings to society as a whole due to the mine; only the results for transportation costs represent the net savings.

4.3 PRICE OF AGGREGATE

Changes in the price of aggregate due to the mine reflect the changes in total undiscounted expenditures on aggregate (because consumption of aggregate is assumed to be the same with and without the mine). As shown in the second row of Table 3, total discounted expenditures on aggregate fall 0.6 percent in the base case. Undiscounted expenditures fall 0.7 percent, which is consistent with the differences in average price shown for selected years at the bottom the table.[7] Figure 4 plots the average aggregate price in the study area with and without the mine between 2003 and 2027 in the base case. Prices with and without the mine are identical for most years between 2003 and 2027. They rise more slowly with the mine between 2009 and 2016, but by 2017, they are nearly identical again.

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[6]Note that because demand for aggregate is insensitive to price and unit production costs are fixed, there are no deadweight losses in our model.

[7]The average price is the average of the prices in each consumption area in a given year weighted by the consumption in each consumption area.

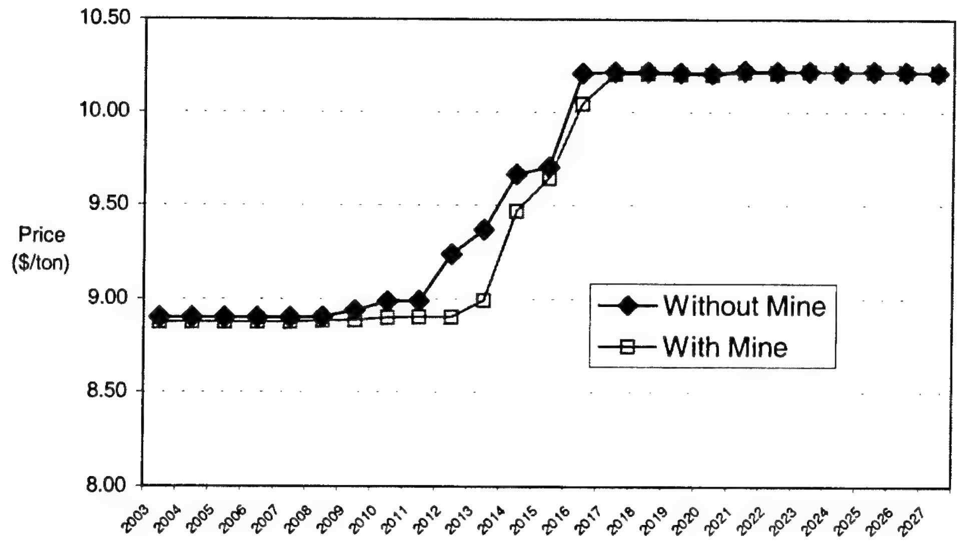

Figure 4—Average Aggregate Price in the Greater Los Angeles Metropolitan Area With and Without the Soledad Mine in the Base Case ($/ton, not discounted)

We predict that the proposed mine could reduce total undiscounted expenditures on aggregate between 2003 and 2027 by as little as 0.2 percent and by a much as 2.2 percent. At the low end of this range, the proposed mine would have almost no effect on aggregate prices, as reflected in the bottom rows of Table 3. At the upper end, prices would be on average 2.2 percent lower (or roughly $0.25 lower per ton) with the mine. At the upper end of this range, price effects would vary by year, amounting to very little change in some years, and up to a 4.5 percent (roughly $0.45 per ton) drop in others.

4.4 AGGREGATE RESERVES AND NUMBER OF MINES IN OPERATION

Of the initial 2,700 million tons of reserves in 1994, the amount remaining in 2027 varies considerably depending on the amount of resources assumed to be converted to reserves by permitting. Without the mine, the amount remaining ranges from 142 million tons (when 5 percent of resources are permitted) to 1.752 billion tons (when 25 percent of resources are permitted). With the mine, the reserves remaining are 56 million tons higher, corresponding to the total expected production from the proposed mine.

Consumption in 2027 is projected to be between 71 million and 85 million tons per year, and when linked to reserves remaining, means that permitted reserves could last 25 more years (through 2052) or be exhausted as soon as 2030. Adding the mine will add less than one year to either date. While in some scenarios there may not be a great deal of

reserves remaining in 2027, a large amount of aggregate resources will still remain. The penultimate line in Table 3 shows that between 12.5 and 12.9 billion tons will remain with or without the mine. Some of these resources may subsequently be converted to reserves.

With or without the proposed mine, the number of production regions operating falls from eight in 2003 (West Ventura ceases production prior to 2003) to four in 2027. As shown in Table 3, the number open in 2027 does not vary much across the various scenarios examined, nor is there a difference in the number open with versus without the mine in any given scenario.

5. SUMMARY AND DISCUSSION

In deciding whether or not to proceed with the proposed Soledad Canyon Mine, one of the factors that should be considered is the effects of the mine on the market for aggregate. We have examined the effects of the proposed mine on the costs of transporting aggregate, economic profits in the industry, and the price of aggregate through 2027. A number of other factors must be considered in deciding whether or not to proceed with the mine, including indirect costs associated with community and environmental impacts, but examination of these factors is beyond the scope of this study.

Based on our analysis, we conclude that the proposed mine will reduce the costs of transporting aggregate by $24 million to $61 million (discounted to year 2000 dollars), or 0.9 to 1.8 percent, between 2003 and 2027. The reduction in costs represents savings to society as a whole due to the reduced fuel, labor, and equipment costs of transporting aggregate from the mine to the consumer.

The proposed mine will also cause economic profits in the mining industry to change. Our analysis suggests that the proposed mine may either increase or decrease economic profits. When combined with the change in transportation costs, the changes in economic profits result in changes in the amount consumers spend on aggregate. We estimate that the mine would cause consumers to spend between $12 million (discounted to year 2000 dollars) and $222 million less to purchase the same amount of aggregate between 2003 and 2027—between a 0.1 and an 2.4 percent drop from a base of $8 to $9 billion. In the lower estimate, higher economic profits partially offset the drop in transportation costs due to the mine. In the higher estimate, the mine causes lower economic profits, reinforcing the drop in transportation costs. Because economic profit represents a transfer from consumers to producer, however, the economic profit component of the $12 million to $222 million range does not represent overall savings to society.

The lower expenditures on aggregate due to the mine reflect declines in the average price of aggregate in the greater Los Angeles metropolitan area. The effect of the mine on average aggregate prices will likely fall between 0.2 and 2.2 percent on average over time. In the lower estimate, prices fall 0.1 percent (or from roughly $10.00 to $9.99 per ton) or less in most all years. In the upper estimate, prices would fall by roughly $0.25 per ton on average between 2003 and 2027. Price declines due to the proposed mine in

the upper estimate vary by year--from no decline in some years to 4.5 percent decline in others.

The effect of this range of price increases on construction activity and overall economic activity in the greater Los Angeles metropolitan area is unknown. To put these changes in perspective, however, we examine their effect on the costs of housing and highways.

Aggregate materials are essential components of housing and highway construction. Approximately 328 tons of sand and gravel are used in the construction of the average 1,500 square-foot home (Southern California Rock Products Association, 2000), and approximately 25,000 tons per lane are required for construction of one mile of highway (Beeby et al., 1999). At a retail price of $8.90 per ton in 2003 (Table 3), aggregate contributes approximately $2,920 to the cost of a home and $0.22 million to the cost of one lane-mile of highway. Assuming an average sales price of a home to be $235,000 (California Association of Realtors, 2000), aggregates contribute approximately 1.2 percent to the price of the average home. One lane of highway can cost between $2 million and $10 million per mile (Southern California Association of Governments, 2000), with aggregates contributing between 2 percent and 11 percent of that overall cost.

Our analysis predicts that the largest average aggregate price decline that could be caused (in a given year) by the proposed mine is 4.5 percent. A 4.5 percent price decline means that the proposed mine would reduce the cost of a new home by about 0.05 percent ($117 on a $235,000 house). And, a 4.5 percent price decline would reduce overall highway construction costs by between 0.09 and 0.50 percent ($10,000 per lane-mile on a highway that costs $2 million to $10 million per lane-mile).

The amount of reserves left in our simulations at the end of 2027 suggests that permitting new resources will remain an issue in the future. In our analysis, we assume that between 5 and 25 percent of the region's resources are converted into reserves between 2003 and 2027. This seems reasonable given past permitting rates. Nonetheless, given the rates of consumption projected for the future, only a small amount of reserves may remain in 2027. If 25 percent of resources are permitted, reserves may last another 25 years, but if only 5 percent of resources are permitted, reserves will run out by 2030. Whether or not the Soledad Canyon mine is permitted will have little effect on the situation--the 56 million tons that will be mined during the mine's lifetime represent less than one year of consumption at the consumption rates predicted for the future.

The projected growth in consumption and the continued pressure on reserves points to the critical need for comprehensive, long-term planning for construction aggregate

supply in the greater Los Angeles metropolitan area. There will be plenty of resources left in 2027 with or without the mine (between 12.5 and 12.9 billion tons), as long as access to even a relatively modest fraction is not encroached upon by urban development. Thus the opportunity to plan for future permitting will remain. Permitting the Soledad Canyon Mine alone in the absence of a more comprehensive plan will make little difference. Focusing on long-range and region-wide strategies rather than single mines may provide the opportunity to satisfy construction aggregate demand in a way that is more amenable to the needs of all stakeholders. Strategies may include substantially reducing the amount of virgin aggregate that is used in construction, permitting resources far in excess of those permitted by the proposed mine, or planning projects that reduce the costs of transporting aggregate from greater distances.

APPENDIX

A. DETAILS OF THE SIMULATION MODEL

This appendix describes the economic model and numerical techniques we use to analyze the market for aggregate in the greater Los Angeles metropolitan area. In each year between 1994 and 2027 we seek to predict

- the consumption of aggregate in each of the 46 consumption areas
- the amount of aggregate each of the nine production regions supplies to each consumption area
- the price of aggregate in each consumption area
- the total costs of transporting aggregate from the production regions to the consumption areas
- the economic profits of each production region.

The demand for aggregate in each consumption area is assumed to be proportional to the population in each area. Demand in thus assumed to be insensitive to price over the range of prices considered here. Demand is undoubtedly somewhat sensitive to price in reality, and further analysis is needed to understand how introducing price sensitivity will affect the outcomes of interest.

Once the quantity demanded is decoupled from price, a few assumptions allow us to determine the amount of aggregate sold by each production region to each consumption area in a straightforward way. We assume (1) that the different production regions compete with each other for customers and do not collude to set prices or divide the market and (2) that the firms within each individual production region do not collude. We also assume that the cost of producing aggregate is the same at all mines. Production costs may not be the same at all mines, but we have no information on the variation of production costs across production regions so impose this condition in our analysis. Under the above conditions, the pattern of production and distribution that would be observed in the aggregate industry is the one that minimizes total transportation costs.

To see that the pattern of production and distribution is the one that minimizes transportation costs, consider the following. First, consider a group of consumption areas that is served by two or more production regions that have annual production limits that are not binding. Competition within each production region will force the free-on-board price (price excluding transportation cost) down to the production cost. Consumers will chose that production region that is closest to them and will pay according to their distance from the production region. The resulting pattern of production and distribution thus minimizes transportation costs.

Now assume that a new production region begins producing but that it can only produce up to some limited amount. The economic profit the new entrant earns is determined by the difference between (1) the distance from the consumption area to the production region originally serving it and (2) the distance from the consumption area to the new production region. The entrant will maximize profits by selling to those consumption areas where this difference is the largest. Such an outcome is the same as would be produced if the objective were to minimize transportation costs: To minimize transportation costs, one would pick the consumption area where the difference between (1) the distance from the consumption area to the new production region and (2) the distance from the area to the displaced production region is the largest.

Consequently, we determine flows of aggregate from each production region to each consumption area by solving the following:

$$(1) \quad Min\sum_{ij} t_{ij}\, prod_{ij}$$

such that

$$\sum_{j} prod_{ij} \leq plimit_i \quad i=1....9.$$

$$\sum_{i} prod_{ij} = c_j \qquad j=1...46.$$

where

t_{ij} is the cost of transporting aggregate per ton from production region i to consumption area j,

$prod_{ij}$ is the amount of aggregate produced in production region i that is sold to consumption area j,

$plimit_i$ is the production limit in region i,

c_j is consumption in area j.

We set the minimization problem above up as a linear program and solve for $prod_{ij}$. Total transportation costs can subsequently be determined.

We now turn to the prices for aggregate that must hold in each consumption area. Consumers in a consumption area can chose to buy aggregate from any production region. Consumers will choose the production regions that can provide aggregate at the lowest cost, including transportation costs. Thus, if production region i sells aggregate in consumption area j and there is no price discrimination (the fob price in a production region is the same for all customers), the following must hold:

$$(2) \quad fob_i + t_{ij} \leq fob_k + t_{kj} \quad k = 1...9, \text{ k not equal to i.}$$

where

fob_i is the selling price of aggregate at production region i (free-on-board price, or price excluding transportation costs).

Similarly, if production region i does not sell material in consumption area j, then

(3) $fob_i + t_{ij} \geq fob_k + t_{kj}$ for all k that sell to area j.

We use the inequalities in (2) and (3) combined with an assumption about the fob price in production regions where the production limit is not binding to develop upper and lower bounds for the fob price at each of the production regions. We assume that competition among mines in each production region where production is below its production limit drives the fob price down to production cost. In each of our scenarios, there is always at least one production region where production is below the production limit (otherwise--except in rare circumstances--total production across all regions would not be adequate to satisfy demand). Such mines provide the values needed to anchor the inequalities in (2) and (3).

To calculate the upper and lower bounds we set up an algorithm that iterates until the fob values converge. We start the algorithm with a vector of fob values whose components equal production costs for those production regions where the production limit is not binding and are missing otherwise. The resulting upper and lower bounds for the fob price at each production region are averaged to yield a point estimate of the fob at each region still in production.

The price in consumption area j is subsequently determined by

(4) $p_j = fob_i + t_{ij}$ for each region i that sells to j.

If multiple production regions sell to the same consumption area, the price in the area is determined by taking the weighted average of the prices corresponding to the relevant production regions. The weights are based on the relative sales of each production region to the consumption area.

Economic profits are profits in excess of the normal return to capital. When the fob price equals the production cost, economic profits are zero, although the firms are still earning the normal return on capital. When fob price rises above production costs, firms earn positive economic profits. We calculate the economic profits for production region i using the following:

(5) $\sum_j (fob_i - pr\cos t_i) prod_{ij}$

where

$pr\cos t_i$ is production cost for region i.

B. SENSITIVITY ANALYSIS

In order to measure the sensitivity of the results to our assumptions for initial reserves, annual production capacity limits, and annual per capita consumption rates, we ran additional scenarios changing one of these three parameters while holding the other two at their base-case values. The results are listed in Table B. The ranges were chosen to highlight the effect of individual parameters and are not necessarily the expected ranges for these parameters. Scenarios combining the expected ranges of these parameters to give small and large effects of the Soledad Canyon Mine are discussed in Section 3.5.

Table B

Sensitivity of Predicted Results to Changes in Individual Parameters

	Transportation Costs 1994 – 2027 ($millions)			Economic Profits 1994 – 2027 ($millions)			Reserves Remaining in 2027 (millions of tons)		
	With Mine	Without Mine	Change	With Mine	Without Mine	Change	With Mine	Without Mine	Change
Increase in Reserves (percent of resources added)									
5 percent	4,902	4,964	-61	375	356	19	198	142	56
10 percent (base case)	4,716	4,775	-59	305	308	-3	534	478	56
25 percent	4,312	4,352	-41	161	284	-123	1,616	1,560	56
Annual Production Capacity Limits									
Historic maximum	4,715	4,767	-52	808	762	46	534	478	56
Base case	4,716	4,775	-59	305	308	-3	534	478	56
Twice base case	4,669	4,719	-50	115	98	17	534	478	56
No limit	4,598	4,639	-41	14	13	0.5	534	478	56
Per Capita Consumption (tons per capita per year)									
3.1	4,213	4,256	-43	231	230	-0.5	725	669	56
3.4 (base case)	4,717	4,775	-59	305	308	-3	534	478	56
3.7	5,234	5,287	-54	447	523	-76	342	286	56

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